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DSTO Landmine Detection Test Targets

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ABSTRACT

DSTO has designed and manufactured a series of landmine test targets to facilitate its active landmine countermeasures program. The targets were developed to simulate specific landmines or to emulate classes of landmines by providing signatures equivalent to those of real landmines. The signatures of the simulant and surrogate landmines were verified against real landmines in a series of experiments involving multiple landmine detection sensors. The test targets are suitable for use with metal detector, ground probing radar, thermal imaging, and seismic/sonic mine detection sensors. Targets are also painted for use on the ground surface with electro-optical imaging sensors. This document details the landmine detection test targets developed by, and available at DSTO Edinburgh, Weapons System Division. Also described are the equivalent targets developed by the United States and Canada. DSTO's test targets, test sites and testing procedures meet the requirements of international test standards.

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Executive Summary

DSTO has an active landmine countermeasures program and works with international organisations on means of reducing the landmine problem. To facilitate this detection effort, DSTO has developed a series of landmine test targets. These test targets were developed to simulate specific landmines or to emulate classes of landmines. The simulant and surrogate landmines were compared with real landmines, where possible, to ensure the signatures were appropriate across commonly used landmine detection sensors. The test targets are suitable for metal detector, ground probing radar, thermal imaging and seismic/sonic detection systems. Painted targets are suitable as surface laid targets for electro-optical and systems such as hyper-spectral imagers.

The decision to use purpose built test targets arose from considerations of safety, convenience, and potential political concerns that could arise with the use of large numbers of real landmines. It was also determined that specific landmines manufactured in different years and factories could vary widely in their signature responses so there was no benefit in using the real landmine bodies exclusively.

This document details the landmine detection test targets developed at DSTO Edinburgh and comparable test targets manufactured in the United States and Canada. DSTO test targets, test sites and test procedures meet the international standards defined in the International Test Operation Procedures guidelines (ITOP 4-2-520, 4-2-521 and 4-2-523) for Countermine and Humanitarian Demining Equipment.

Authors

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Ian Chant obtained a BSc in Physics from Griffith University in 1979 and an Honours Degree in 1980. He subsequently worked in geophysical research at Macquarie University in the area of Magneto Tellurics survey methods. He obtained a MSc in this field from the University of Queensland in 1987 and a PhD in 1992. He currently works in Landmine Detection in Weapons System Division at the Defence Sceince and Technology Organisation, Edinburgh, South Australia.

Darren Lee
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Darren Lee graduated with Honours in a Bachelor of Applied Science (Applied Physics) degree from the University of South Australia. In 1997 he joined DSTO's Countermine (Detection) group specialising in hand-held mine detection technologies including the metal detector and ground penetrating radar. In 2001, Darren's work focus shifted to vehicle width mine detection systems. Darren's research interests include software development, signal processing and the application of electromagnetic techniques for the detection of mines. Darren works as a member of the Threat Mitigation Group in Weapons Systems Division at DSTO Edinburgh, South Australia.

Daryl Ireland
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Daryl Ireland began work as a Weapons Research Establishment apprentice in 1966 and has worked in DSTO ever since. He obtained a Bachelor of Technology (BTech) in Computronics and Management in 1997. This qualification was awarded by Deakin University (Melbourne). Since 2001, he has worked in navigation, countermine and computing technology areas, contributing to a multi-sensor mine detection system. This work has been carried out in the Threat Mitigation Group of Weapons Systems Division at DSTO Edinburgh, South Australia.

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Glossary

ADF	Australian Defence Force
AG	Action Group (TTCP)
AP	Anti-Personnel
AT	Anti-Tank
AV	Anti-Vehicle
DRDC	Defence Research and Development Canada
DSTO	Defence Science and Technology Organisation
FFE	Free From Explosives (ITOP)
GPR	Ground Probing Radar (also termed Surface Penetrating Radar)
ITEP	International Test and Evaluation Procedure
ITOP	International Test Operations Procedure
LMT	Land landmine Target (ITOP)
MD	Metal Detector
NVESD	Night Vision and Electronic Sensor Directorate, CENCOM (USA)
PVC	Poly Vinyl Chloride
RDX	Rapid Detonating Explosive (Hexahydro-Trinitro-Triazine)
RTV	Room Temperature Vulcanizing
SEN	Sensor branch (TTCP)
SES	Scientific and Engineering Services (DSTO)
SIM	Simulant mine-like Target (ITOP)
STT	Standard Test Target (ITOP)
SUM	Surrogate mine-like Target (ITOP)
TI	Thermal Imaging
TNT	Trinitrotoluene
TTCP	The Technical Cooperation Panel

1. Introduction

As an aid to testing and developing landmine detection technologies DSTO has produced a series of test targets. These targets were developed to simulate specific landmines or to emulate a class of landmines and were designed to have appropriate signatures for the sensors being used with the targets. The decisions to construct simulant and surrogate test targets were made for safety, handling, storage and political reasons, and because actual landmines bodies were difficult to obtain. The simulant and surrogate landmines were compared with real landmines where possible to ensure signatures were equivalent. It was also determined that specific landmines manufactured at different times and in different factories could vary widely in their signature responses so there was little benefit in using the real landmine bodies exclusively.

The following document primarily details landmine detection test targets developed at DSTO Edinburgh, Weapons System Division to date. Some instrumented landmines used for pressure testing are also mentioned. DSTO also possesses samples of landmine test targets provided by TTCP partners. These targets, made available through TTCP SEN AG23, are used for comparison of test and evaluation procedures. All DSTO landmine detection test and evaluation is undertaken according to international standards.

2. Standards

All targets and test procedures at DSTO conform to the International Test and Evaluation Program for Humanitarian Demining [1]. The Night Vision and Electronic Sensor Directorate (NVESD) at Fort Belvoir, Washington developed this protocol and SEN AG23 contributed to its definition as MIL-PRF-23359H. The protocol was subsequently accepted by NATO as STANAG 4587 and by the ABCA nations as QSTAG 1347 on test methodology for standoff and hand held detection arrays detailed in International Test Operations Procedures (ITOP) 4-2-520, 4-2-521 and 4-2-523.

2.1 Terms/Definitions.

The following definitions are summarised from the ITOP 4-2-521. Targets may be live landmines, surrogates or simulant landmines.

2.1.1 Live Landmine Target

A Live Landmine Target (LMT) is a tactical, live, completely and fully functional production landmine.

a. Type 1 Target is a fully functional production landmine.
    i. Type 1A Target is a Type 1 Target without the main explosive, yet with an active/live fuze.

2.1.2 Standard Test Target

A Standard Test Target (STT) is a simulant or surrogate landmine used in the test of landmine detection systems. They are intended to interact with countermine systems in a way representative of, or identical to, that of a real landmine or landmine category.

2.1.2.1 Simulant Landmine

A simulant landmine (SIM) is an STT that has features or characteristics representative of a 'category' of landmine types, but does not replicate any specific landmine type or model.

a. Type 5 Target - A SIM that contains some explosives and possibly a fuze.
b. Type 6 Target - A SIM that is fully Inert/ Free From Explosive (FFE).

2.1.2.2 Surrogate Landmine

A STT that lacks some (one or more) features or characteristics of an actual landmine 'type or model' is called a Surrogate landmine (SUM).

a. Type 2 Target - A production landmine rendered safe so that the fuze cannot operate.
b. Type 3 Target - A production landmine FFE.
    i. Type 3B Target, the removed explosive is replaced with an inert material.
c. Type 4 Target - A reproduction landmine usually FFE.
    i. Type 4A Target has air in lieu of explosive.
    ii. Type 4B Target has an inert material in lieu of explosive.
    iii. Type 4C Target has explosive but usually rendered safe so that the fuze cannot operate.

2.1.2.3 Instrumented Landmine

Usually used in clearing or breaching equipment testing.

a. Type 7 Target: A SIM or SUM that has been instrumented to determine if a disturbance would have initiated or detonated the target.

2.1.2.4 Calibration or Canonical Target

A non-mine target used especially for detection equipment testing.

a. Type 8 Target - May be a STT, as defined above or of simple construction such as a PVC or metal cylinder.

2.1.3 Target Array

This may be a minefield or an array of weapons. Target arrays may consist of LMTs, STTs or a combination of both.

3. DSTO landmine test targets

DSTO has designed and manufactured a number of surrogate and simulant landmines. These targets are listed below according to the ITOP definitions. The DSTO test targets use paraffin wax and nylon beads to simulate the explosive fill. The nylon beads increase the net dielectric constant of the surrogate explosive fill to better reflect that of TNT and RDX explosive. This surrogate explosive is cheaper than the Dow Corning RTV 3110 Silicone used by the US SIM but does have certain problems. The heating of paraffin wax gives off a mildly carcinogenic vapour and so filling is undertaken in a fume cupboard. The wax also expands when heated so landmines are only filled to 1 cm from the rim. Fortunately, this air gap also simulates the air gap found between the top of the explosive and the casing in a real landmine. This air gap provides a large signature for Ground Penetrating Radar (GPR) returns from non-metal cased landmines. Under normal operating conditions, where the test targets are buried in the ground they will be unaffected by hot conditions. However if the landmines are used above ground in direct sunlight the wax may melt in which case the RTV compound should be used instead.

3.1 Real Targets

A number of real landmines were procured for validation against simulant and surrogate targets. These include FFE landmine bodies, explosive filled de-fuzed landmines (Type 2 SUM), and wax and nylon filled real landmines (Type 3 SUM). As per the Ottawa agreement to which Australia is a signatory, these landmines have been listed and declared to the United Nations forum on demining.

However since real landmine bodies are effectively 'an unloaded weapon' these landmines are tracked and inventoried and used sparingly for field analysis[1]. Most DSTO work is undertaken using reproductions and simulants.

3.2 Simulant Targets

Simulants represent a particular 'class of landmines'. Some simulants are painted and simulants of various size and shapes are provided for imaging sensor experiments. Commercial water based paint was used to give the landmine surfaces the green or sand coloured finish suitable for visible surface landmine imaging experiments. Dulux Weather Shield paint in Sandman and Olive Drab colour was used. DSTO has a range of Type 6 SIM landmines with either metallic or non-metallic cases. Non-metal cased landmines have cavities for various inserts to be placed.

[1] For availability of Type 2 and Type 3 targets, contact authors at DSTO Edinburgh.

The simulant landmines designed and manufactured by DSTO are listed in Appendix A. Appendix A also includes photographs and diagrams for construction. The following tables summarises the nomenclature used by DSTO to describe the landmine simulants.

Table 1: Nomenclature for landmine type based on usage and effect

Landmine Type		**Comments**
Anti-tank	AT	Anti-tank or anti-vehicle
Anti-personnel	AP	Blast type
Fragmentation	FR	Anti-personnel bounding or stake mounted, area or directional
Off-route	OR	Anti-tank or anti-vehicle, directional attack
Improvised	IM	Could be local product or may contain one or more of the types above as well as additional explosive
Bar	BR	Anti-track landmines, long thin shape laid horizontally

Table 2: Nomenclature for landmine casings

Case material		**Comments**
Non-metallic case	NM	Usually described by Contents material
Metal case	M	Conductive case
Wood case	WD	Special subset of NM case

A separate designation is given to wood and naturally occurring cased landmines, as natural materials generally have different optical properties to artificial materials.

Table 3: Nomenclature for physical shape, size and weight

Physical Shape and Size		**Comments**
Cylindrical	C	Cylindrical landmine, 'diameter' D 'depth'
Box	X	Box type landmine, 'longest top side' X 'shortest top side' X 'depth'
Bar	B	Track cutting bar mines
Large, cylindrical, AP	L	> 10 cm diameter
Small, cylindrical, AP	S	≤ 10 cm diameter

DSTO defines the naming convention for simulant landmines as Type+Case+Shape/Size. Therefore, a small non-metallic cased cylindrical antipersonnel landmine would be assigned the convention of 'APNMS'. Such a class of surrogate landmine whose diameter is approximately 5cm is representative of the M14, Type72A and Type72B landmines. As DSTO produces only one simulant landmine in each category there is no overlap in definitions.

Furthermore, the addition of landmine inserts in the non-metallic landmine cases allows the simulant landmine bodies to fall within different metal content classes described in Table 4. This nomenclature is not used as part of the naming convention but is useful for describing the STT for electromagnetic based landmine detection characteristic testing including technologies of metal induction and ground probing radar.

Table 4: Definition for the metallic content of non-metallic cased landmines

Metal Content		Comments
High metal content	HM	> 10g metal
Low metal content	LM	≤10g metal
No metal content	ZM	0g metal

3.3 Surrogate Targets

Surrogate landmines accurately depict the signature of 'a particular live landmine'. These Type 4 SUM landmines were mainly designed for detection simulations based on ADF assistance to Cambodian de-mining. The exception is the M14 surrogate that was chosen as a particularly difficult target due to its size and metal content. These targets have similar electromagnetic, thermal and mass signatures to the actual landmines. They are suitable as metal detector, seismic/sonic, GPR and buried thermal targets. They are not suitable for surface deployment for optical techniques unless painted with an appropriate colour. They are marked 'INERT' if they are FFE.

Surrogate landmines available at DSTO are listed in Appendix B with photographs and construction plans for each. DSTO nomenclature for naming SUM landmines is to use the Janes 'landmine and landmine clearance' designation suffixed by '–S'.

3.4 Calibration (Canonical) Targets

Canonical or Calibration Type 8 targets are currently used by DSTO for detector comparison testing and generating data for the physical modelling of detectors. The lists given in Table 5, Table 6 and Table 7 below can be varied as required.

Table 5: DSTO electromagnetic sensor calibration targets

Designation	Description	GPR	MD	TI
SS 05D05	Stainless steel, cylinder, solid, 5 cm diameter, 5 cm high	x	x	x
SS 05D10	Stainless steel, cylinder, solid, 5 cm diameter, 10 cm high	x	x	x
SS 05D15	Stainless steel, cylinder, solid, 5 cm diameter, 15 cm high	x	x	x
SS 10D05	Stainless steel, cylinder, solid, 10 cm diameter, 5 cm high	x	x	x
SS 10D10	Stainless steel, cylinder, solid, 10 cm diameter, 10 cm high	x	x	x
SS 10D15	Stainless steel, cylinder, solid, 10 cm diameter, 15 cm high	x	x	x
SS 15D05	Stainless steel, cylinder, solid, 15 cm diameter, 5 cm high	x	x	x
SS 15D10	Stainless steel, cylinder, solid, 15 cm diameter, 10 cm high	x	x	x
SS 15D15	Stainless steel, cylinder, solid, 15 cm diameter, 15 cm high	x	x	x
TIN 26D10	Tin, cylinder, hollow, 26.5 cm diameter, 10 cm high.	x	x	
GS 32D50	Galvanised steel, pipe, hollow, 32 cm diameter, 50 cm long, ends capped	x	x	
GS 45D50	Galvanised Steel, pipe, hollow, 45 cm diameter, 50 cm long, ends capped	x	x	

GS 75D50	Galvanised Steel, pipe, hollow, 75 cm diameter, 50 cm long, ends capped	x	x	
PVC 05D05	PVC, cylinder, solid, 5 cm diameter, 5 cm high	x		x
PVC 05D10	PVC, cylinder, solid, 5 cm diameter, 10 cm high	x		x
PVC 05D15	PVC, cylinder, solid, 5 cm diameter, 15 cm high	x		x
PVC 10D05	PVC, cylinder, solid, 10 cm diameter, 5 cm high	x		x
PVC 10D10	PVC, cylinder, solid, 10 cm diameter, 10 cm high	x		x
PVC 10D15	PVC, cylinder, solid, 10 cm diameter, 15 cm high	x		x
PVC 25D15	PVC, cylinder, solid, 25 cm diameter and 15 cm high	x		x
PVC 25D15H	PVC, cylinder, solid, 25 cm diameter and 15 cm high, halved through axis of rotation	x		x
PVC 32D50	PVC, pipe, hollow, 32 cm diameter, 50 cm long, ends capped	x		
PVC 45D50	PVC, pipe, hollow, 45 cm diameter, 50 cm long, ends capped	x		
PVC 75D50	PVC, pipe, hollow, 75 cm diameter, 50 cm long, ends capped	x		

Table 6: DSTO thermal imaging calibration targets

Designation	**Description**	**GPR**	**MD**	**TI**
WX 5D5	PVC, cylinder, paraffin wax filled, 5 cm diameter, 5 cm high	x		x
WXN 5D5	PVC, cylinder, paraffin wax and nylon filled, 5 cm diameter, 5 cm high	x		x
CC 15D15	Concrete, cylinder, 15 cm diameter, 15 cm high	x		x

Table 7: DSTO metal detector calibration targets

Designation	**Description**
AL 1G	Aluminium cylindrical, 1g, , metal off cut
MS 1G	Mild steel cylindrical, 1g, metal off cut
SS 0.5G	Stainless steel cylindrical, 0.5, metal off cut
SS 1G	Stainless steel cylindrical, 1g metal off cut
BR 0.5G	Brass cylindrical, 0.5g, metal off cut
BR 1G	Brass cylindrical, 1g, metal off cut
N5	Detonator casing No. 5 for TMA-1A landmine
M64	Detonator casing M46 for M14 landmine
Table 8	**Inserts as per US NVESD specification**
Figure 4	**Inserts as per Canadian DRDC specification**

3.5 Instrumented Simulant Targets

DSTO has a number of pressure-instrumented Type 7 SIM landmines of the AP and AV sizes. Designs for these landmines area held by the Scientific and Engineering Services section of DSTO Edinburgh.

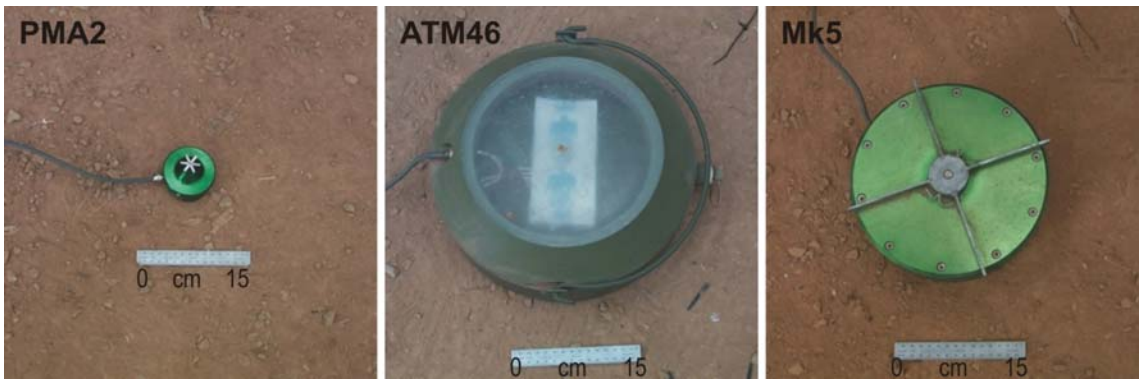

Figure 1: DSTO instrumented simulant mines

3.6 Simulant Inserts

DSTO utilises a set of inserts modelled after the US NVESD and Canadian DRDC inserts. These inserts may be used to give a known metal content to any of the non-metallic bodied SIM targets. These inserts and their markings are documented in Appendix C.

4. US NVESD targets and inserts

The following are the US simulant landmine targets. DSTO has two sets of these targets; one is the earlier version with a polystyrene foam ring on the top of the landmine and the second, a latter version, without this ring (*Figure 2*). It has been noted by NVESD that the latter simulants are poor ground probing radar targets due to the lack of an air gap simulated by the polystyrene foam ring in the earlier version. NVESD is looking at modification of these surrogates to rectify this. The NVESD simulants can be fitted with the metal inserts listed in Table 8.

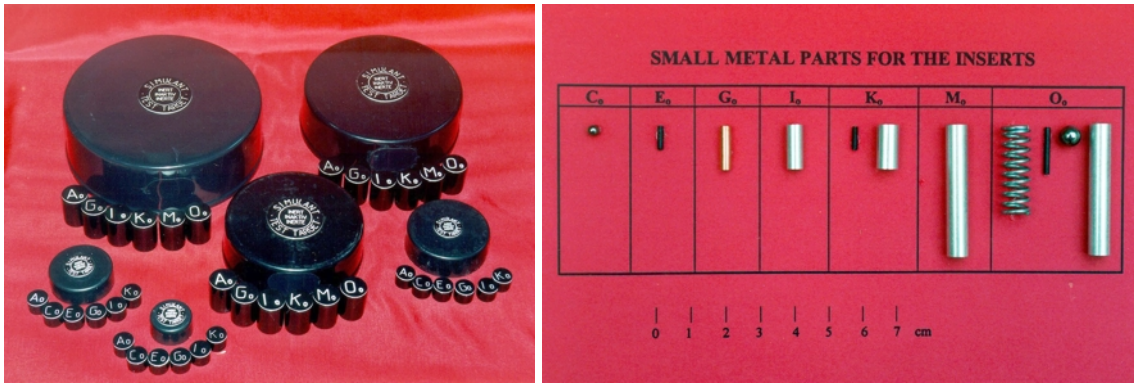

Figure 2: NVESD simulant landmines and inserts

Table 8: NVESD SIM metallic inserts

Levels of Detection (With Metal Detector)	Antipersonnel SIM 12,9 & 6 cm	Antitank SIM 30, 25 & 20 cm	CONTENTS (Potted in Dow Corning RTV 3110 Silicone)
Zero	A_0	A_0	No metal. (RTV Silicone only)
Very Difficult	C_0	NONE	1/8″ diameter [0.131g] carbon steel ball
Very Difficult	E_0	NONE	0.100g carbon steel pin, 0.27″ length x 0.062″ diameter, vertical
Hard to Detect	G_0	G_0	Very small copper tube, 0.5″ length x 0.125″ O.D. x 0.016″ wall thickness [0.393g], vertical
Hard to Detect	I_0	I_0	Small aluminium tube, 0.5″ length x 0.187″ O.D. x 0.015″ wall thickness [0.172g], vertical
Moderately Difficult to Detect	K_0	K_0	Two (2) parts: 0.100g steel pin from E_0 above and small aluminium tube, 0.50″ length x ¼″ O.D. x 0.015″ wall thickness [0.22g], vertical
Moderately Difficult to Detect	NONE	M_0	Large aluminium tube, 1.5″ length x ¼″ diameter x 0.015″ wall thickness [0.66g], vertical
Easiest to Detect	NONE	O_0	Four (4) parts: 0.200g steel pin 0.54″ length x 0.062″ diameter, large aluminium tube from M_0 above, 1.61g carbon steel spring, 1.00″ length x 11/32″ O.D. with 0.041″ diameter (vertical) and a ¼″ diameter [1.060g] carbon steel ball

5. Canadian DRDC Targets

The Defence Research and Development Canada (DRDC) simulant landmine was used in the development of the Foresight detection system and hand held detector testing. The landmine body, Figure 3, will take any of the inserts in Figure 4.

Figure 3: DRDC simulant landmine body

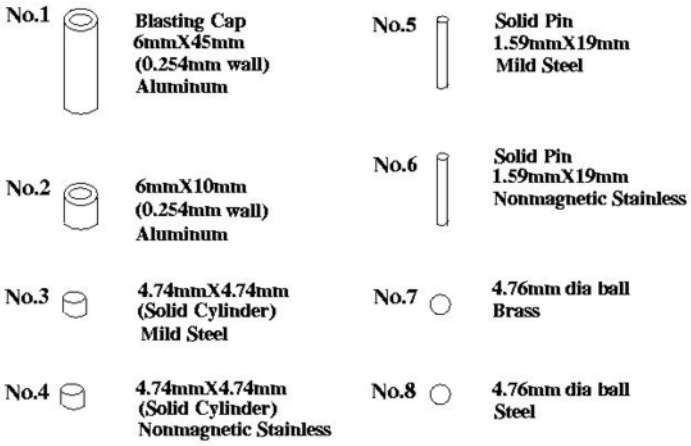

Figure 4: DRDC simulant landmine inserts

6. Conclusions

DSTO has developed an assortment of landmine simulant and surrogate test targets that replicate a range of characteristics found in many landmines by the most commonly used mine detection systems. These test targets are verified against real landmines and are comparable to overseas standards. Duplication of most of these SIM and SUM targets is possible from the plans provided in the appendices to this document. These targets are suitable for metal detector, GPR, Seismic/Sonic and Electro-optical/Thermal Imaging experiments and landmine detection training.

The simulant test targets are representative of actual live landmine target categories and are intended to have generic characteristics of actual live landmine target categories. The surrogate test targets represent specific landmines. All DSTO test targets are safe to store, transport and use, and conform to ITOP standards for Countermine and Humanitarian Demining.

7. References

[1] Scientific and technical report page for simulant mines. Department of Defence's Unexploded Ordnance Center of Excellence (UXOCOE) Web site. Available at: http://www.uxocoe.brtrc.com/techlibrary/TechRpts/misc1.asp.
Accessed 8 February 2005.

Appendix A: DSTO Simulant Target Designs

Table 9: Landmine simulants used in DSTO detection trials

Designation	Description
APNMS	Small non or low metallic content AP landmine simulant, PVC case, adjustable metal content, Paraffin wax and nylon filler[2], Similar to M14, Type72 or PMA-2 etc.
APNMC	Non or low metallic AP landmine simulant, PVC case, adjustable metal content, Paraffin wax and nylon filler[2], Similar to PMN, PMN2, PMA-3 or TS-50, etc.
APNMX	Non or low metallic content AP landmine simulant, Polystyrene box case, adjustable metal content, Paraffin wax and nylon filler[2], Similar to No 4, PMA-1A, TM-100/200/500 etc.
APWDX	Non or low metallic content AP landmine simulant, Wooden box case, adjustable metal content, Paraffin wax and nylon filler[2], Similar to PMD-6, PP Mi-D, PMD-7/57 or Shu landmine.
ATNMC	Non or low metallic content AT landmine simulant, PVC case, adjustable metal content, Paraffin wax and nylon filler[2], Similar to TM62P, TMA-4 or SBMV.
ATNMX	Non or low metallic content AT landmine simulant, Polystyrene case, adjustable metal content, Paraffin wax and nylon filler[2], Similar to TMA-2, TMA-5 or M19.
ATNMB	Non or low metallic content AT bar landmine simulant, PVC case, adjustable metal content, Paraffin wax and nylon filler[2], Similar to L9, AT 3A (used in pairs) or MITRAL.
APMX	Metal AP landmine simulant, Folded metal box case, paraffin wax and nylon filler[2], Refer to Janes database reference M/966B.
FRMC	Metal AP bounding fragmentation landmine simulant, Cylindrical, folded metal case (paint tin), Paraffin wax and nylon filler[2],Similar to M16 series and OZM series.
ATMC	Metal AT landmine simulant, Cylindrical, folded metal case, tilt rod capable, Paraffin wax and nylon filler[2], similar to M15, MK-5, TM62M etc.
ATMX	Metal AT landmine simulant, Folded metal box case, tilt rod capable, Paraffin wax and nylon filler[2], similar to M7A2, TM38 or TM35.

DSTO is currently painting all landmine simulant and surrogate targets 'Olive Drab' or 'Sandman'. All targets are labelled 'INERT' if FFE, and 'DSTO' if space permits.

[2] Paraffin and nylon fillers are appropriate for electromagnetic and thermal-imaging detection. A 1cm air gap allows for thermal expansion of the paraffin wax and provides a simulant of the air gap in explosive filled targets. Other fillers are used for alternate methods (eg. urea or di-nitro-tolulene for explosive detection methods). Where appropriate explosive fillers can also be used.

The simulant landmines in Figure 5 are photographed with a 15cm ruler for scaling.

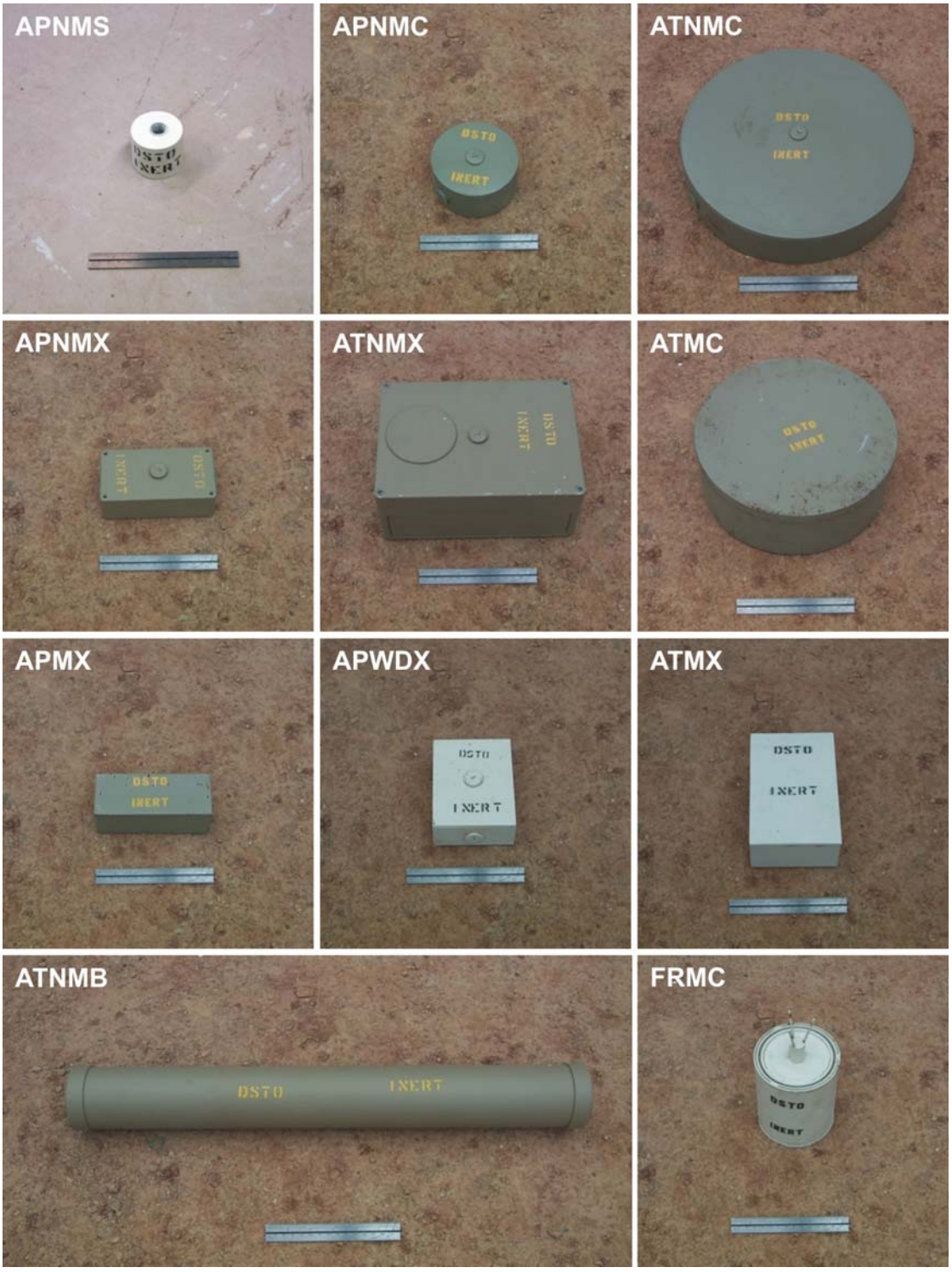

Figure 5: DSTO simulant landmines

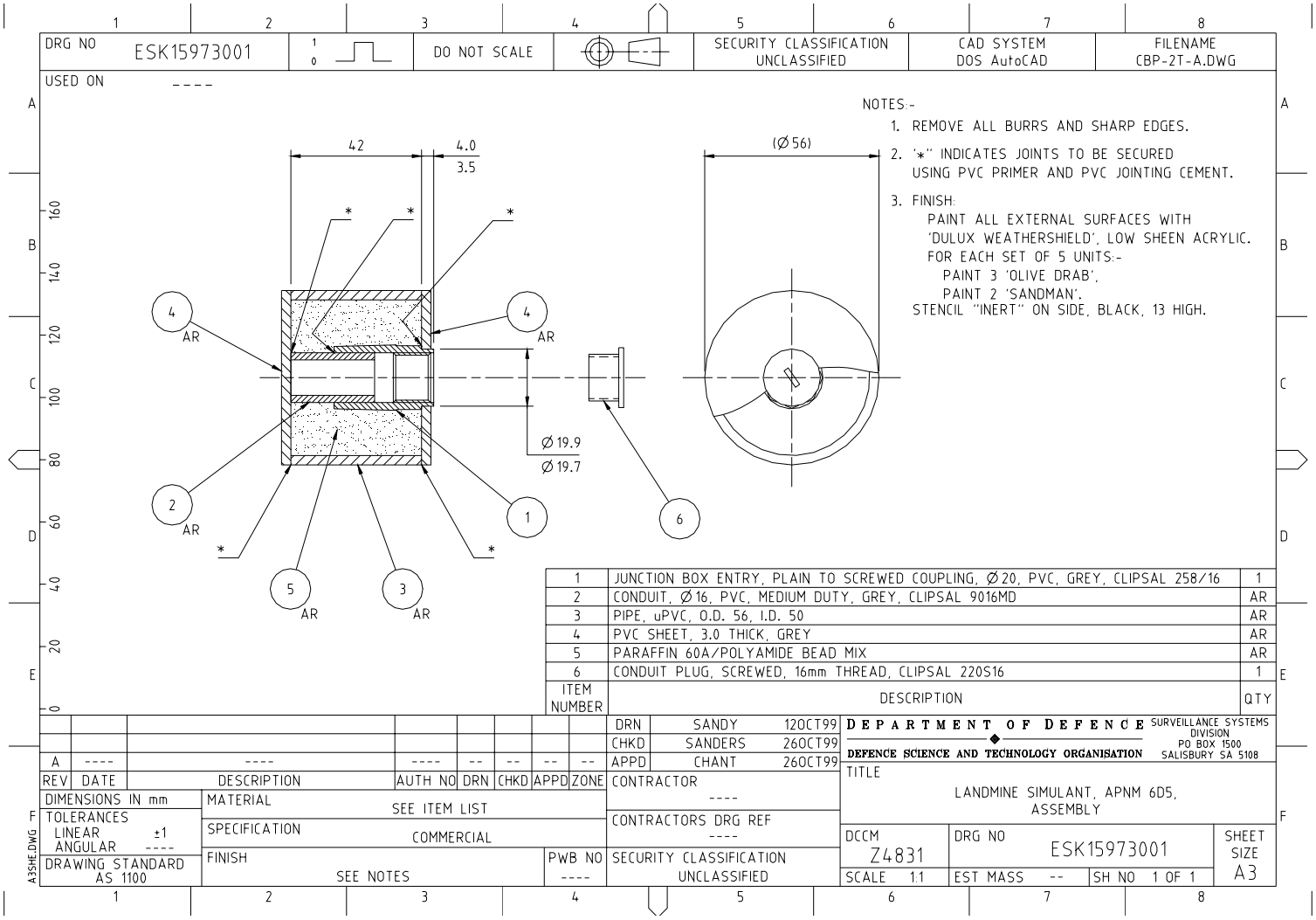

Figure 6: APNMS, non-metallic-cased small-cylindrical anti-personnel blast landmine simulant

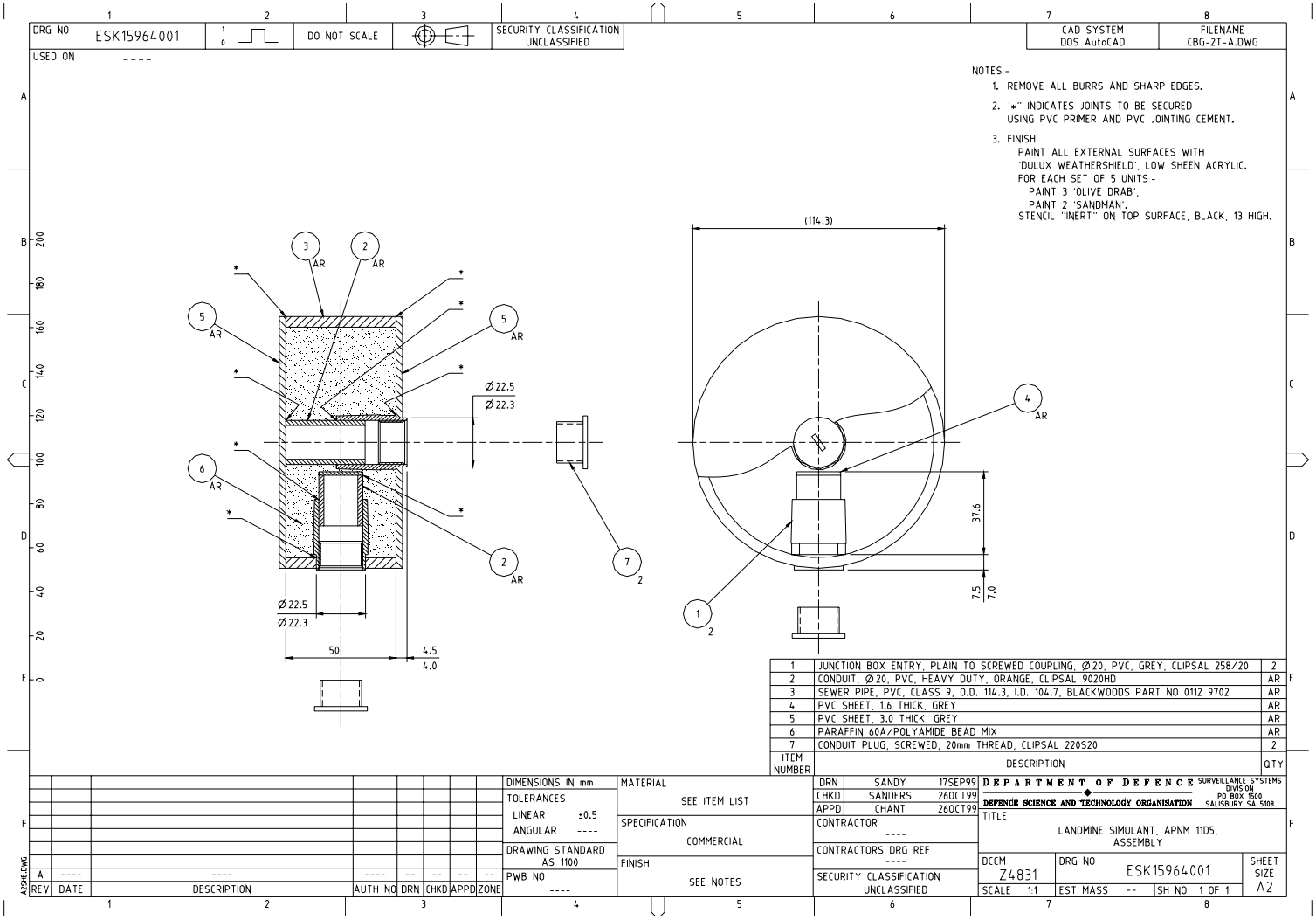

Figure 7: APNMC, non-metallic-cased cylindrical anti-personnel blast landmine simulant

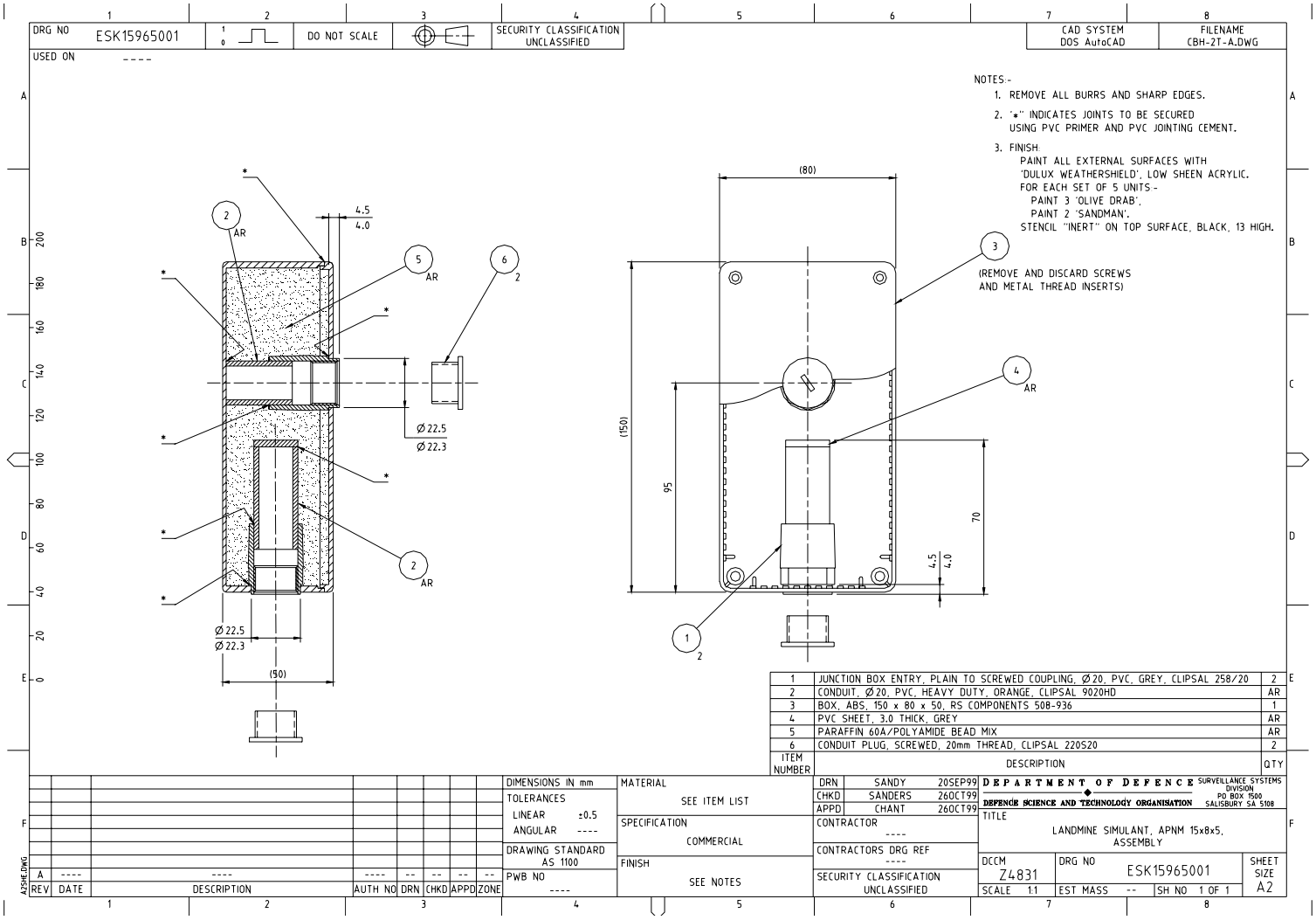

Figure 8: APNMX, non-metallic-cased box-shaped anti-personnel blast landmine simulant

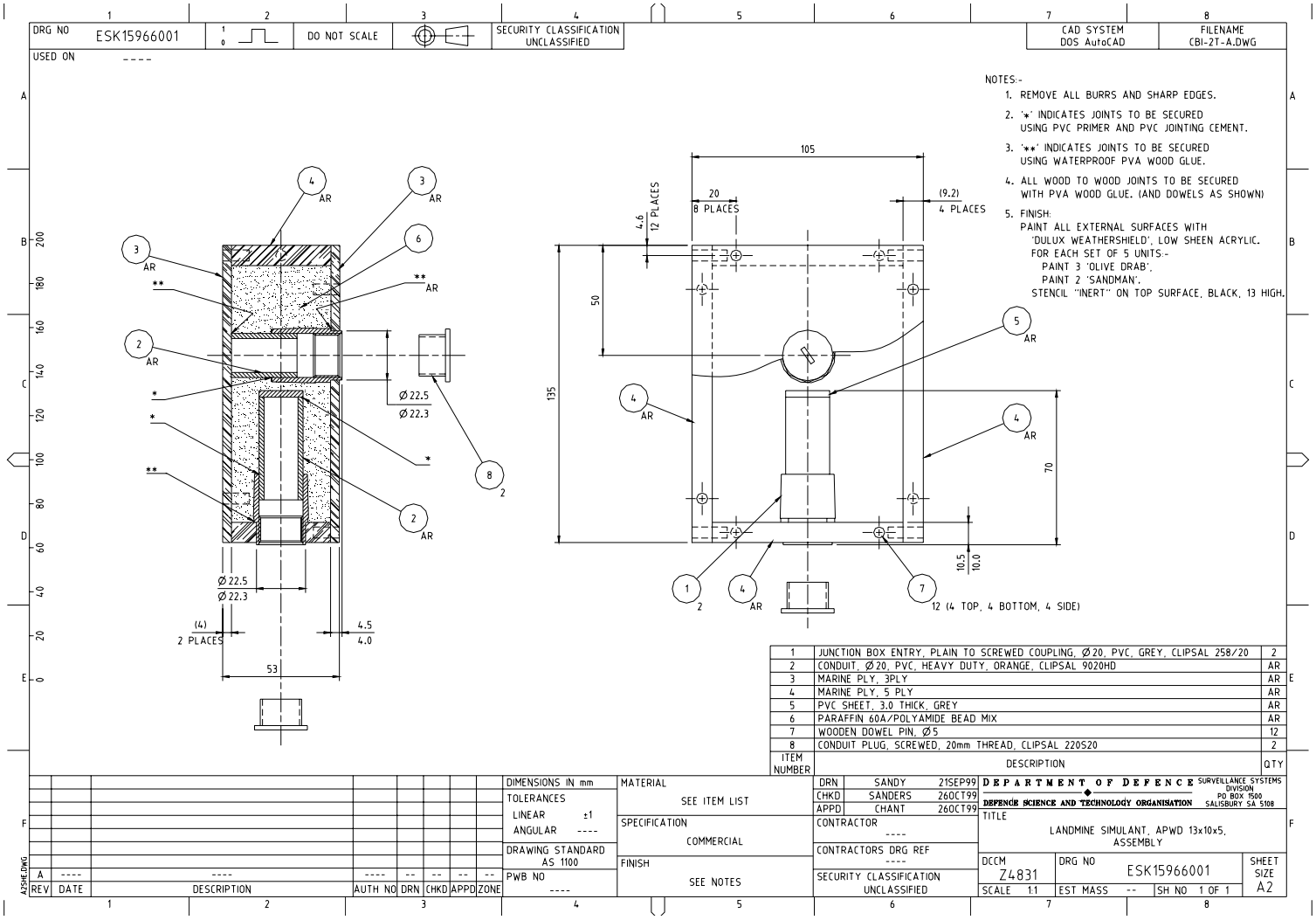

Figure 9: APWDX, wooden-cased box-shaped anti-personnel blast landmine simulant

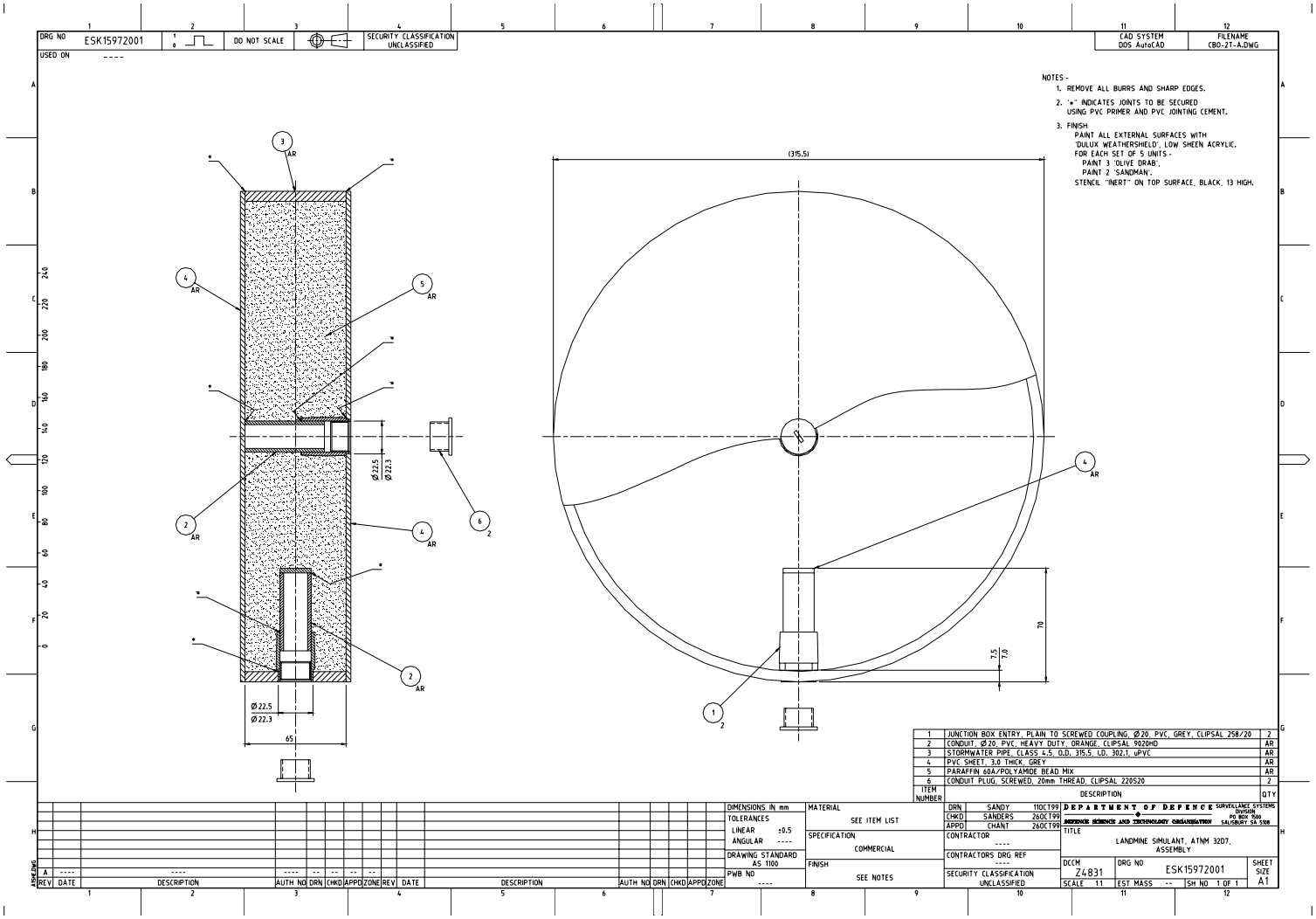

Figure 10: ATNM C, non-metallic-cased cylindrical anti-tank blast landmine simulant

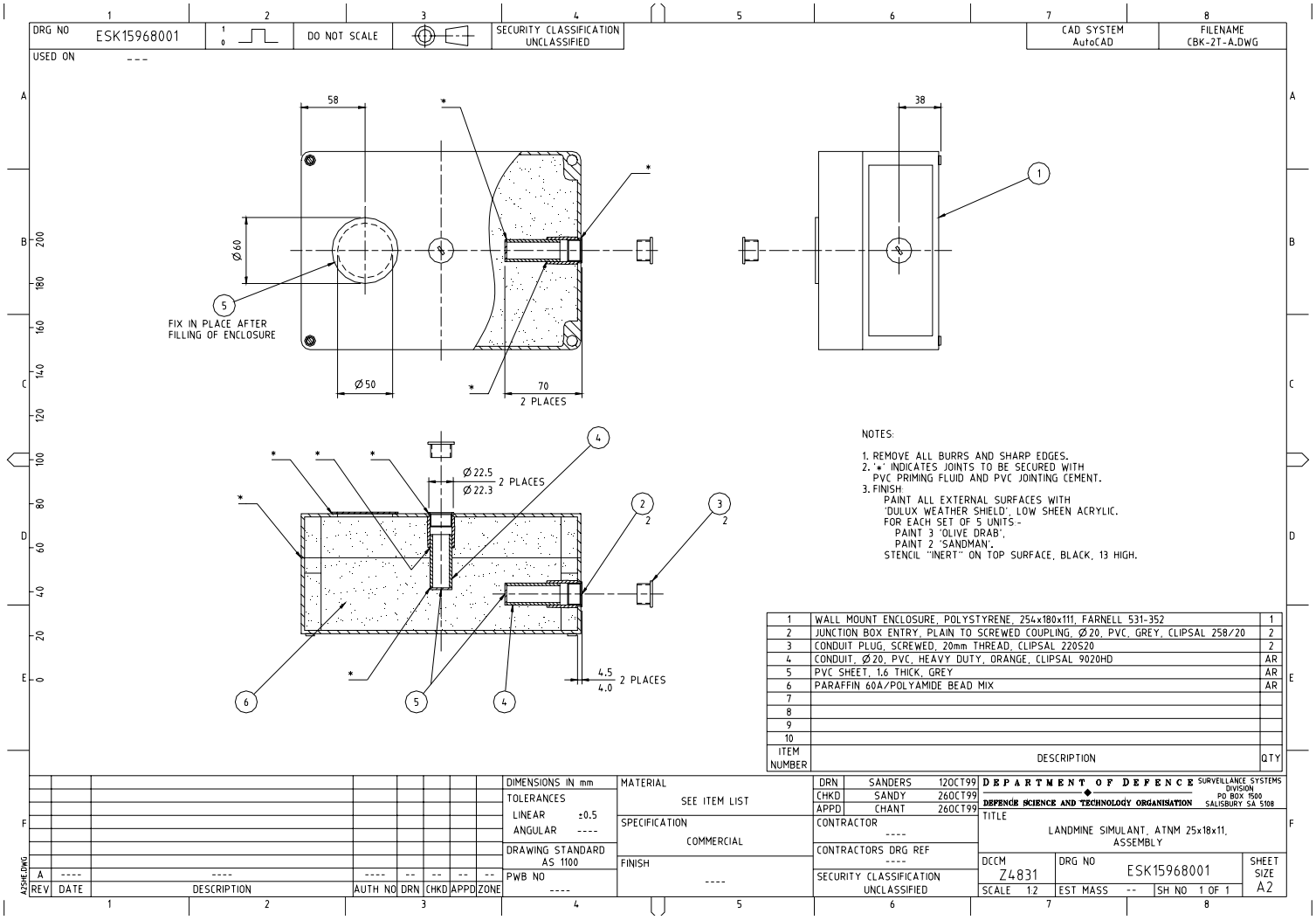

Figure 11: ATNM X, non-metallic-cased box-shaped anti-tank blast landmine simulant

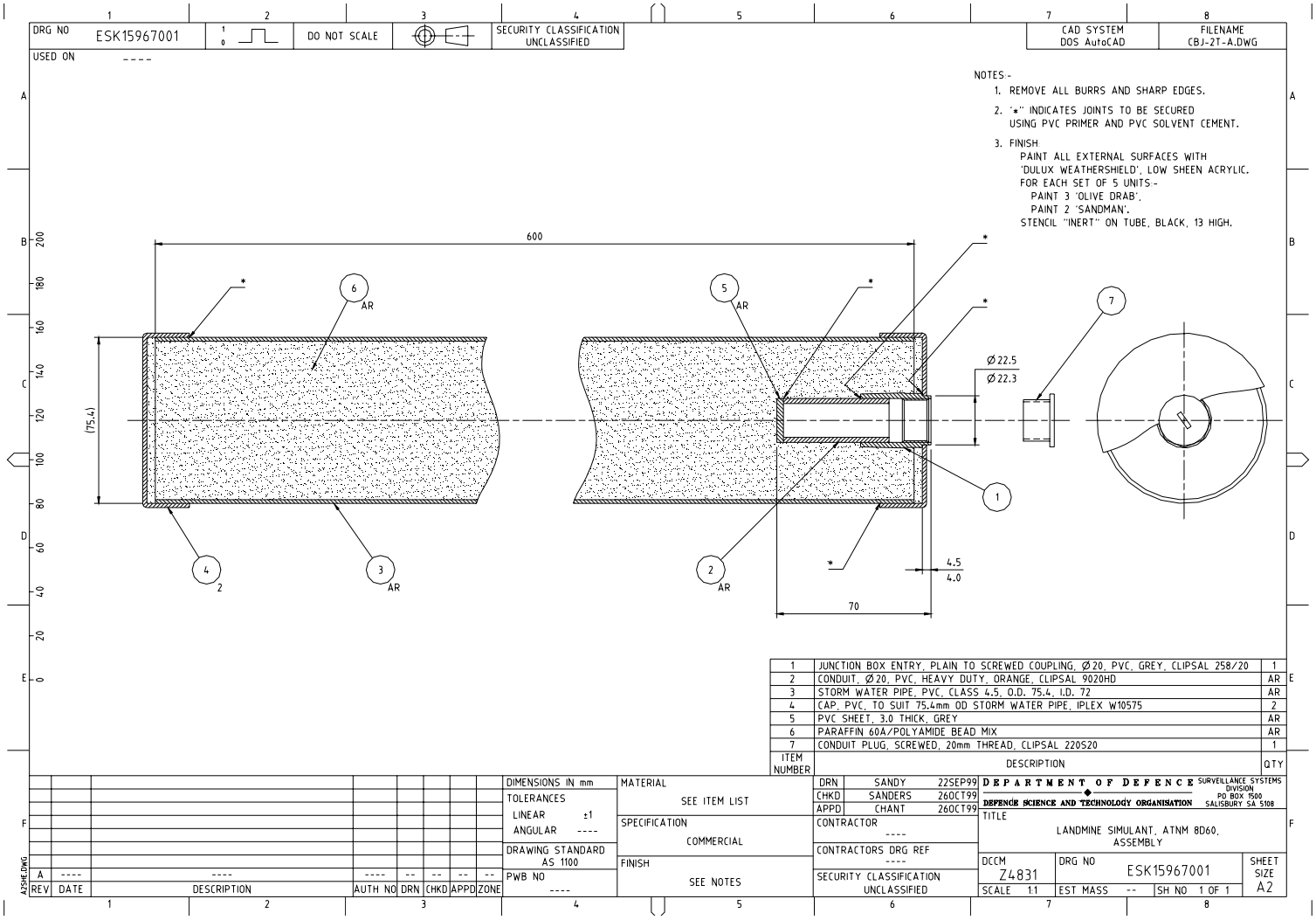

Figure 12: ATNM B, non-metallic-cased bar-shaped anti-track blast landmine simulant

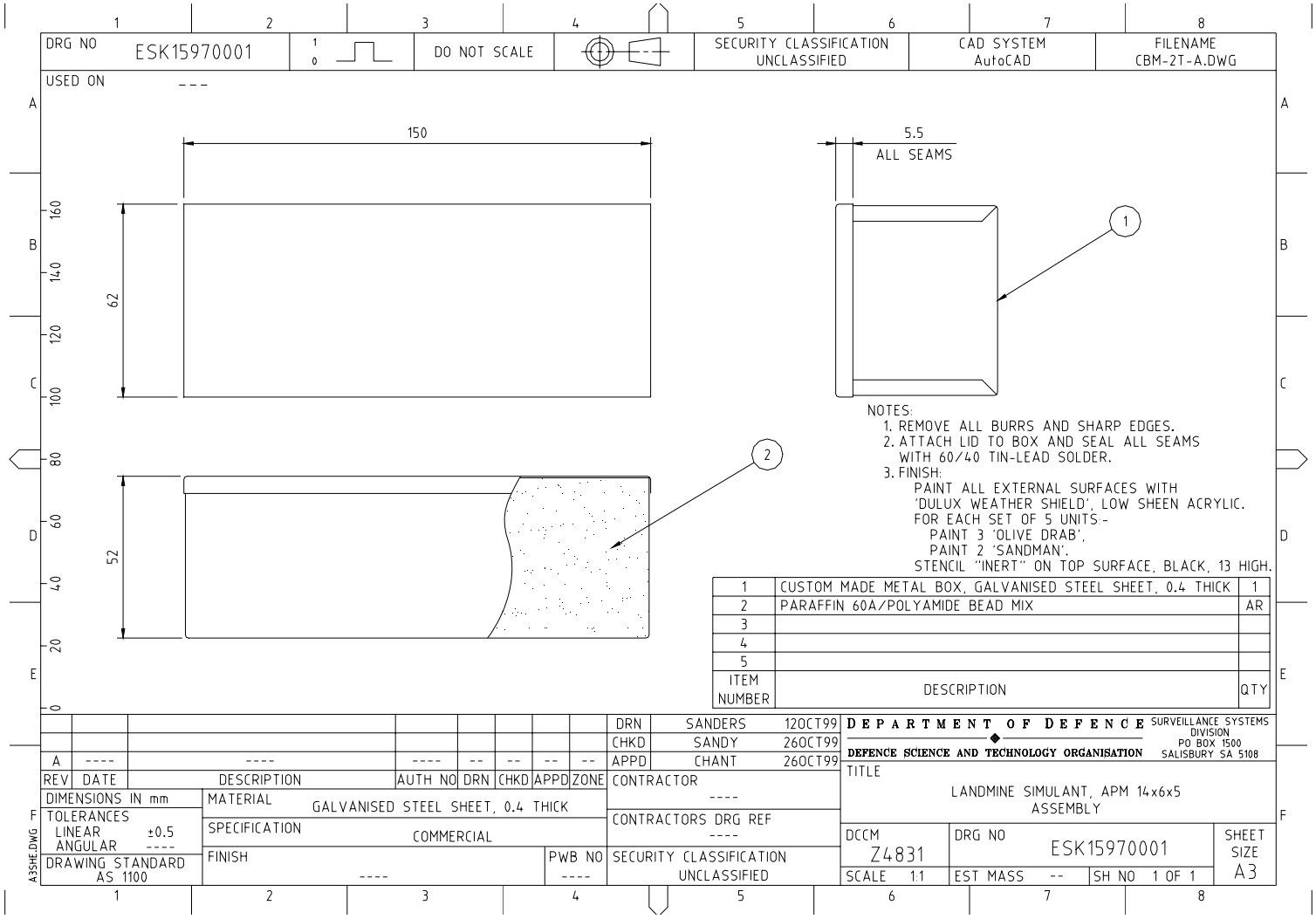

Figure 13: APM X, metallic-cased box-shaped anti-personnel blast landmine simulant

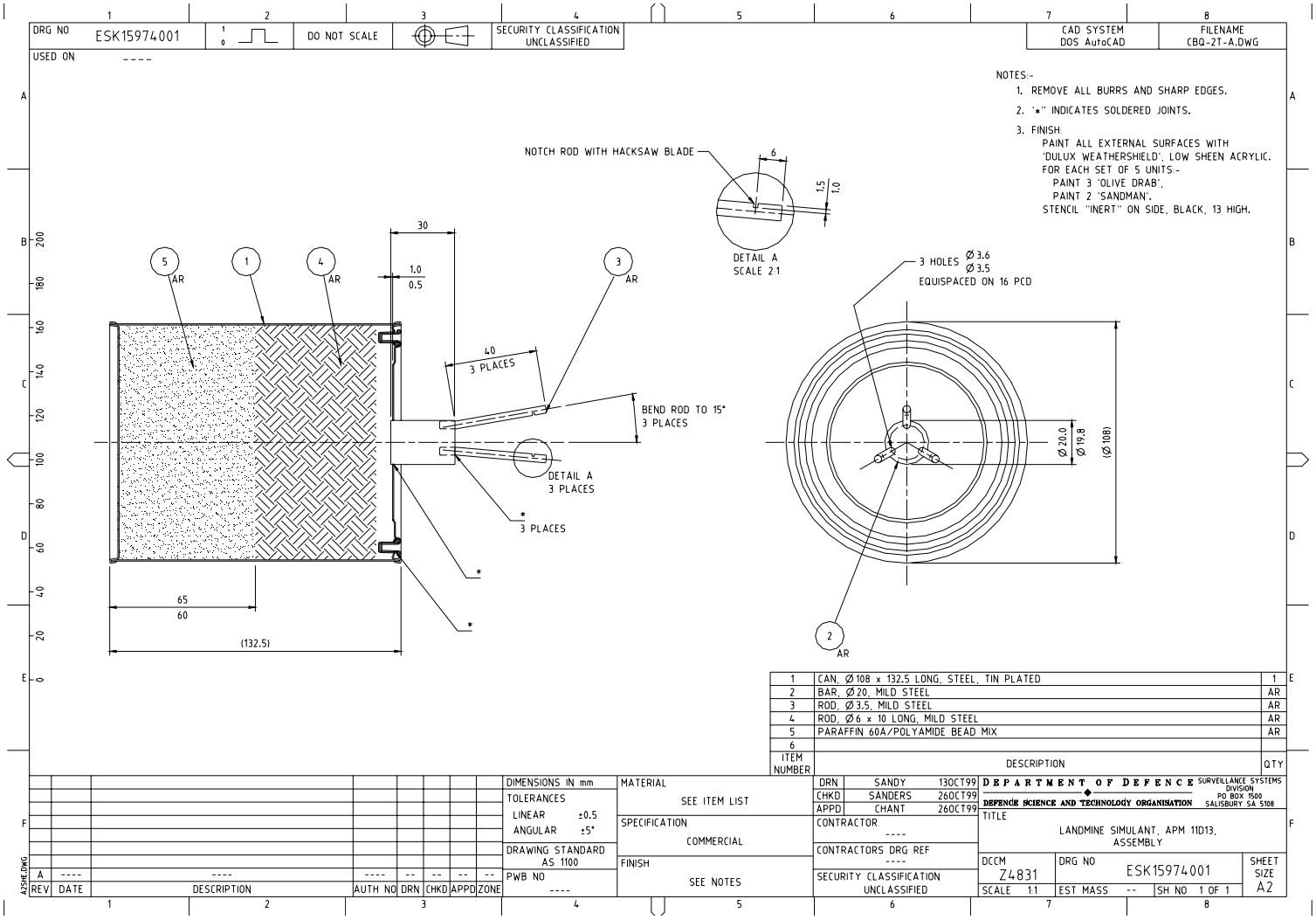

Figure 14: FRMC, metallic-cased cylindrical anti-personnel bounding fragmentation landmine simulant

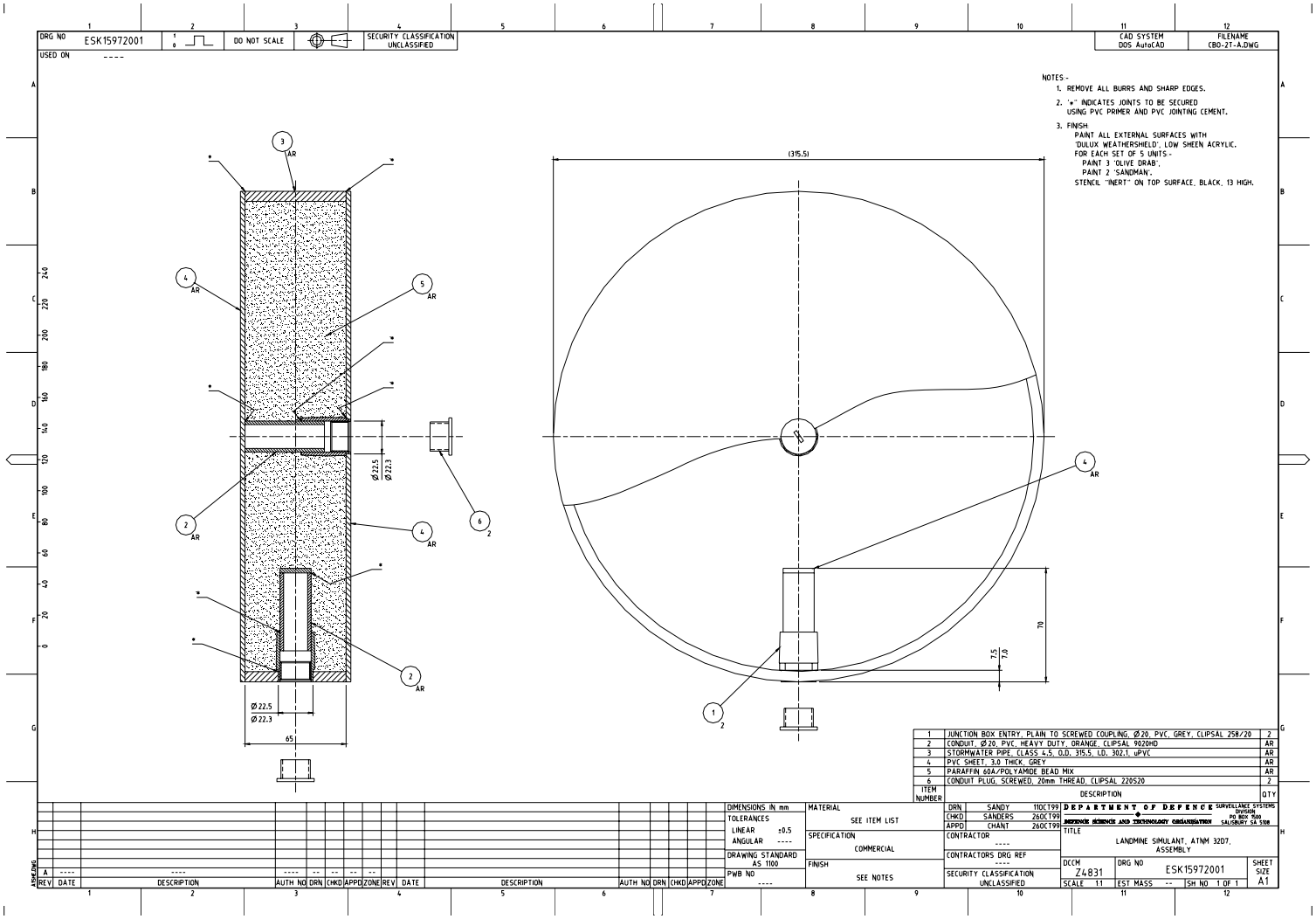

Figure 15: ATM C, metallic-cased cylindrical anti-tank blast landmine simulant, with optional tilt-rod

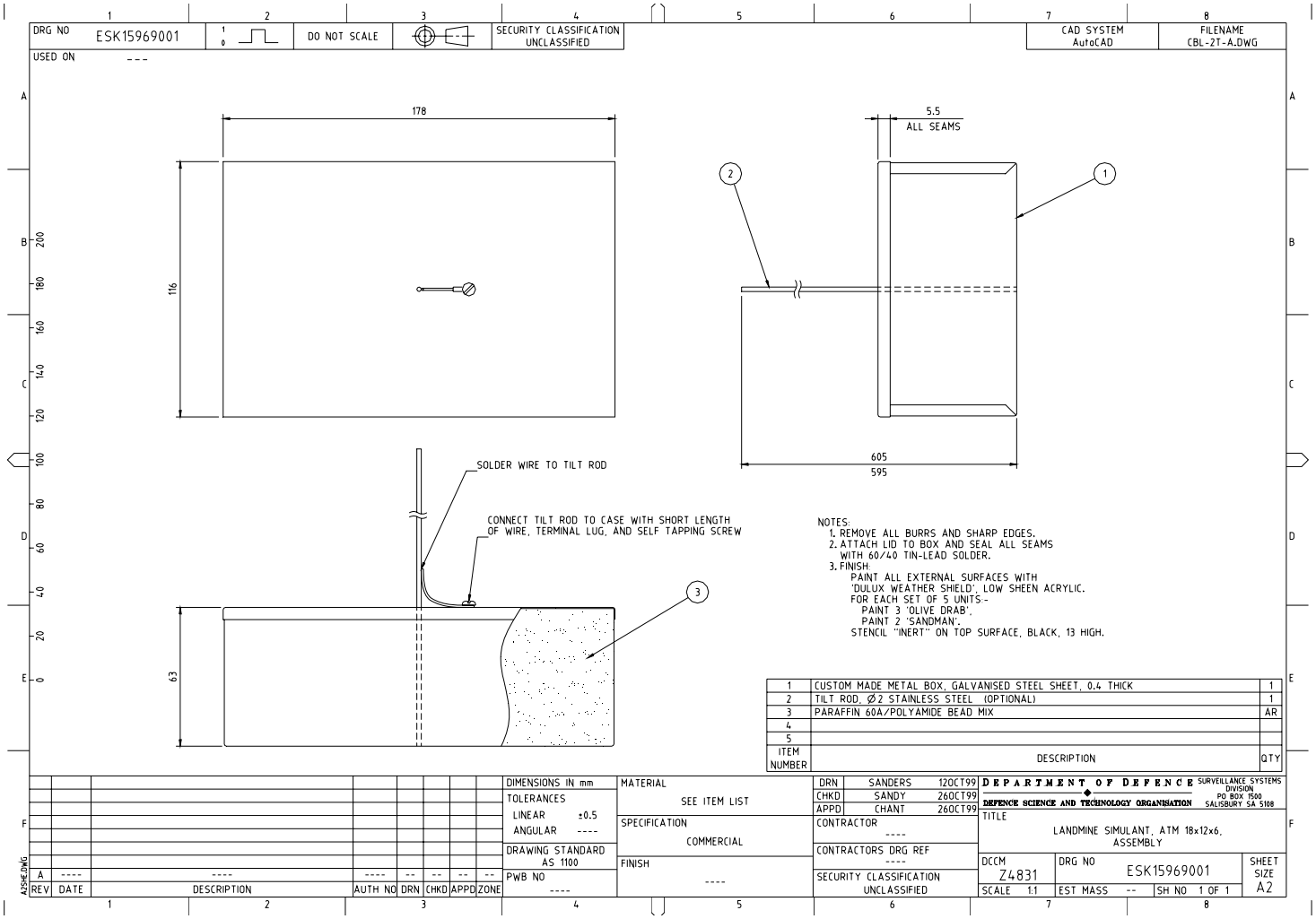

Figure 16: ATM X, metallic-cased box-shaped anti-tank blast landmine-simulant, with optional tilt-rod

Appendix B: DSTO Surrogate Target Designs

Table 10: Surrogate landmines used for DSTO landmine detection trials

Designation[2]	Description
M14-S	M14 AP landmine surrogate, Non-metallic case, low metal content, small size PVC pipe, paraffin wax and nylon filler[3], Appropriate metal parts and simulated fuse.
PMN-S	PMN AP landmine surrogate, Non-metallic case, low metal content, large size PVC, paraffin wax and nylon filler[3], Appropriate metal parts and a simulated fuse.
PMN2-S	PMN-2 AP landmine surrogate, Non-metallic case, low metal content, large size PVC pipe, paraffin wax and nylon filler[3], Appropriate metal parts and a simulated fuse.
PMA1A-S[4]	PMA-1A AP landmine surrogate, Non-metallic case, low metal content, PVC box, paraffin wax and nylon filler, Appropriate simulated fuse.[5]
TM62P-S	TM- 62(P) AT landmine surrogate, Non-metallic case, low metal content PVC pipe, paraffin wax and nylon filler[3], Appropriate metal parts and a simulated fuse.
TMA3-S	TMA AT landmine surrogate, Non-metallic case, low metal content, no filler. Visual target only!

DSTO is currently painting all landmine simulant and surrogate targets 'Olive Drab or Sandman'. All targets are labelled 'INERT' if FFE, and 'DSTO' if space permits.

[2] Mimic the signature of a particular live mine

[3] Paraffin and nylon fillers are appropriate for electromagnetic and thermal-imaging detection. A 1cm air gap allows for thermal expansion of the paraffin wax and provides a simulant of the air gap in explosive filled targets. Other fillers are used for alternate methods (eg. urea or di-nitro-tolulene for explosive detection methods). Where appropriate explosive fillers can also be used.

[4] No drawing available

[5] This is a poor simulant as it lacks the air gap which is classic to this type of landmine. The air gap significantly enhances the GPR signature of this target. Recommend use of APNMX with appropriate insert rather than this surrogate target.

The DSTO surrogate landmines in Figure 17 are photographed with a 15cm ruler for scaling purposes.

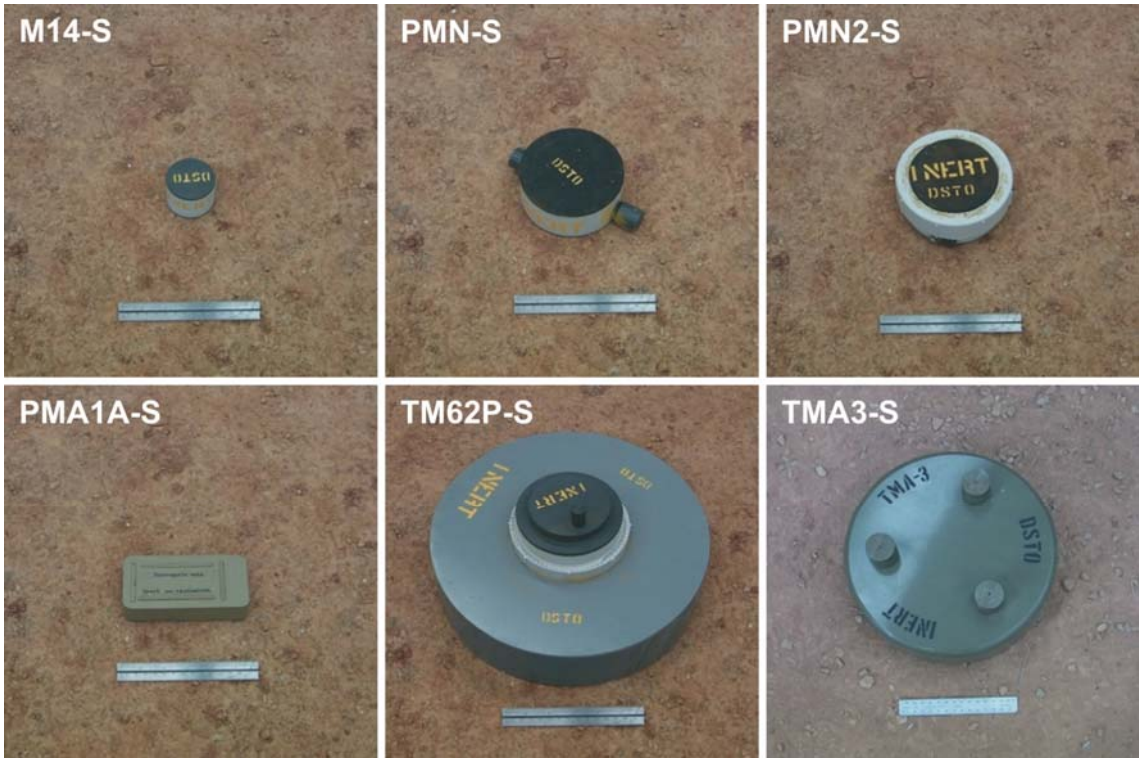

Figure 17: DSTO surrogate landmines

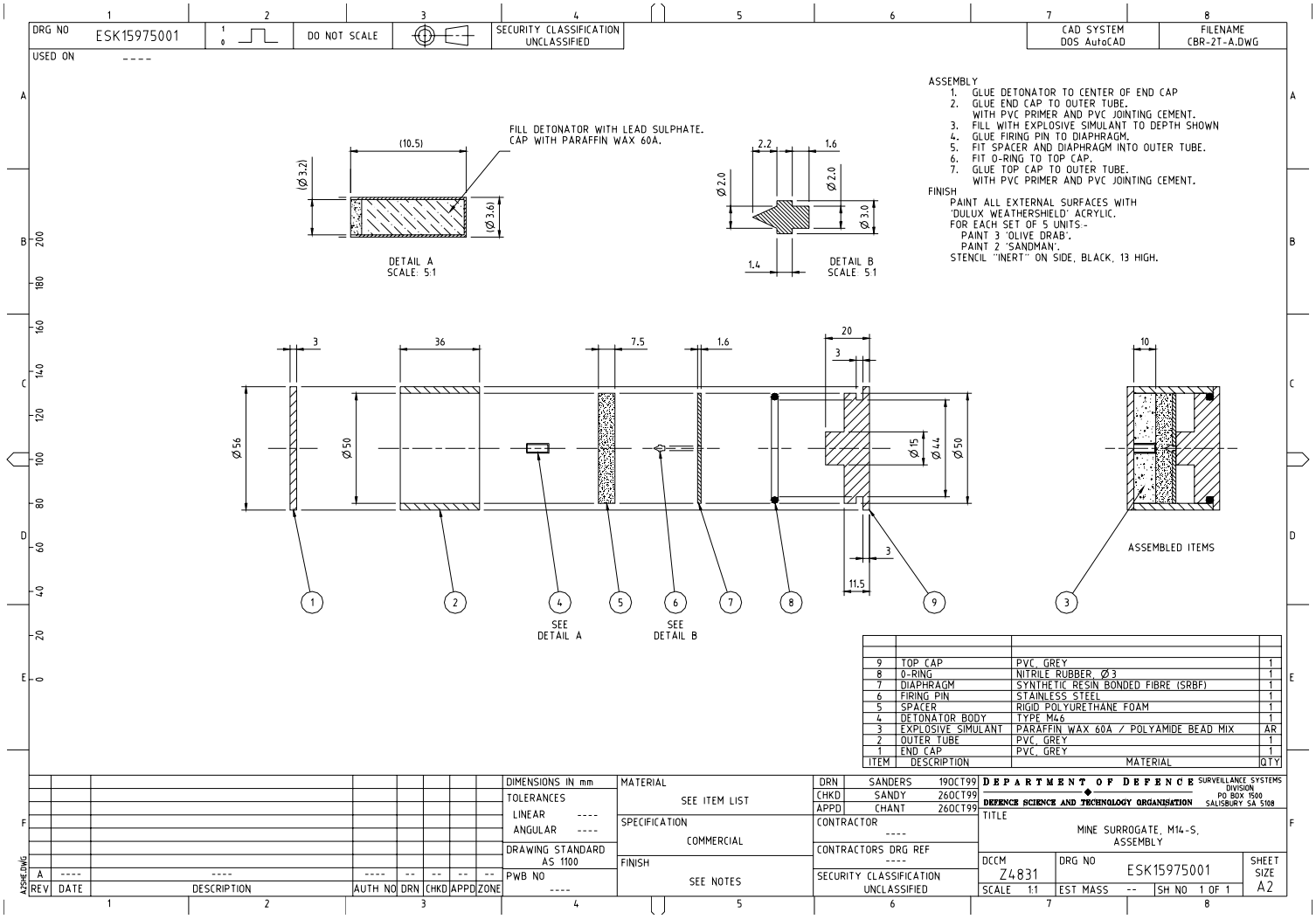

Figure 18: Cutaway drawing of M14-S surrogate landmine

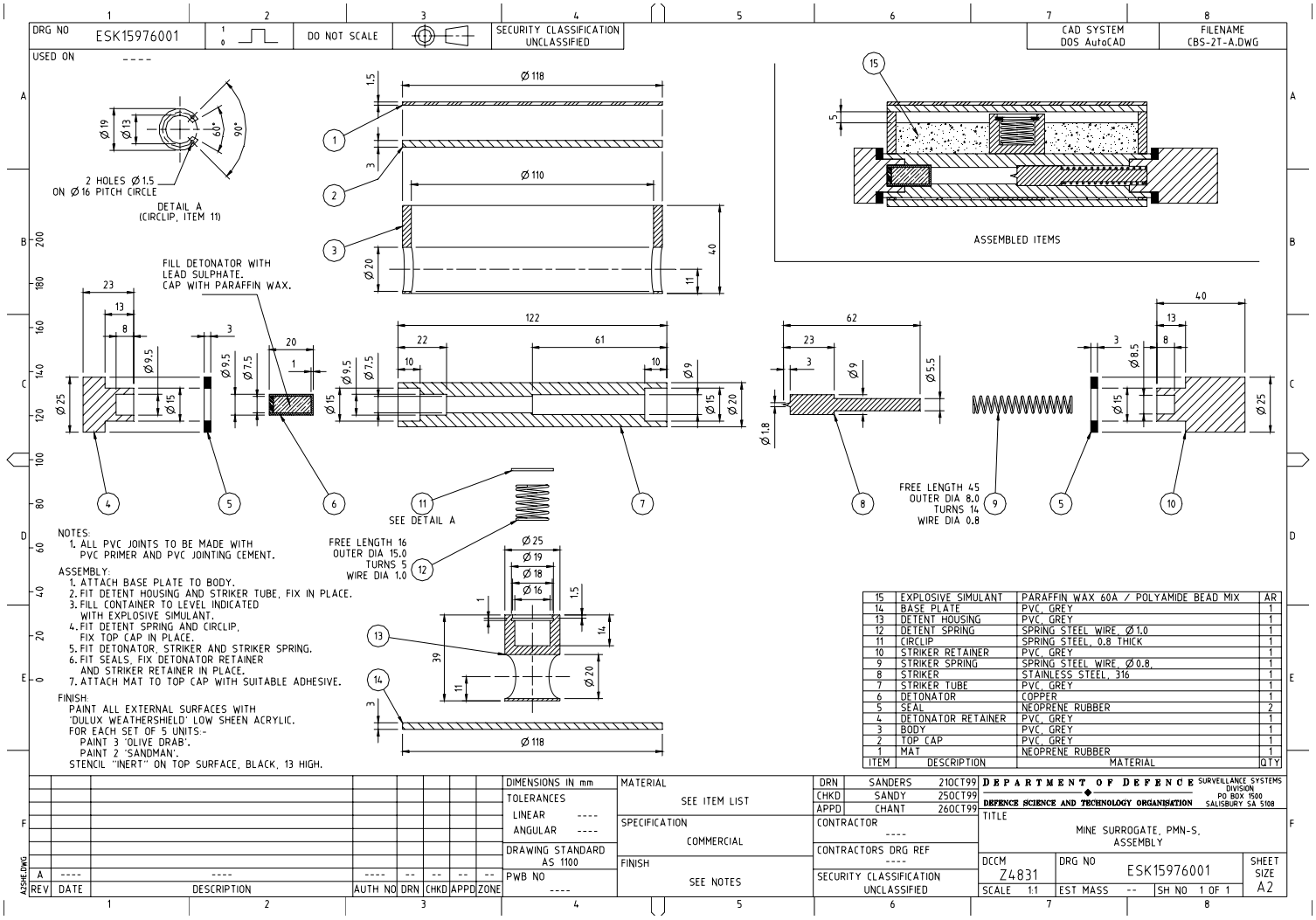

Figure 19: Cutaway drawing of PMN-S surrogate landmine

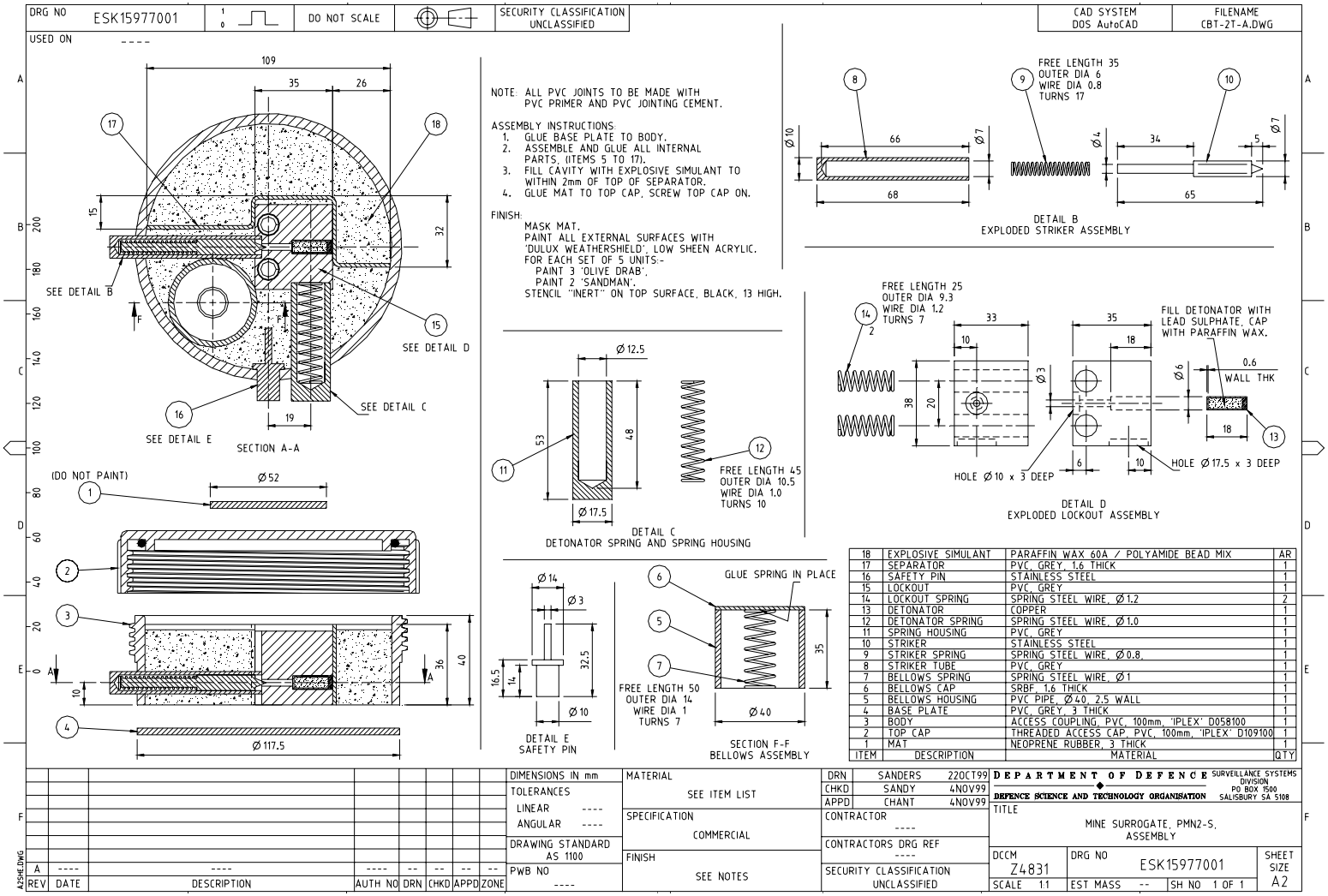

Figure 20: Cutaway drawing of PMN2-S surrogate landmine

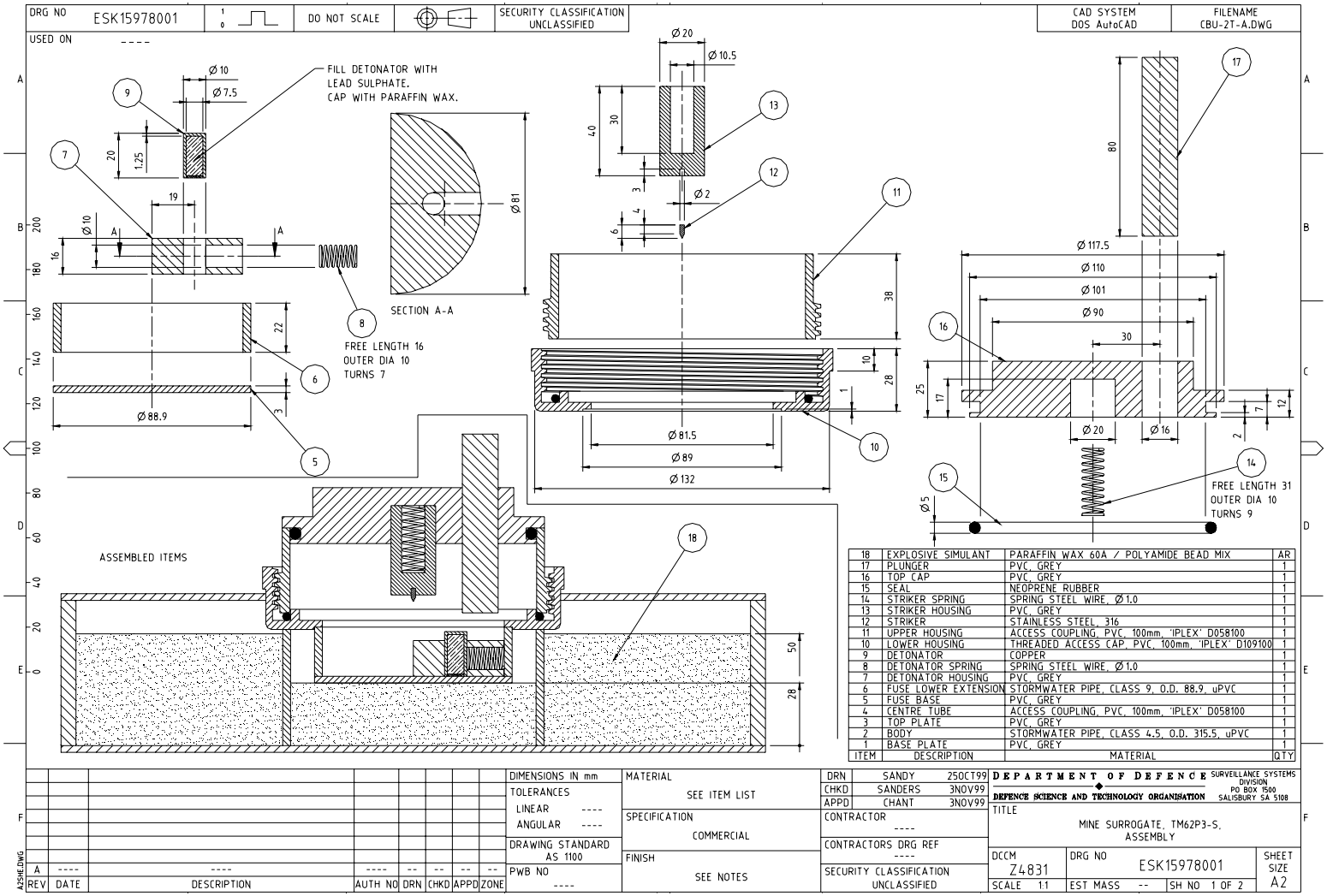

Figure 21: Cutaway drawing of TM62P3-S surrogate landmine (Part A)

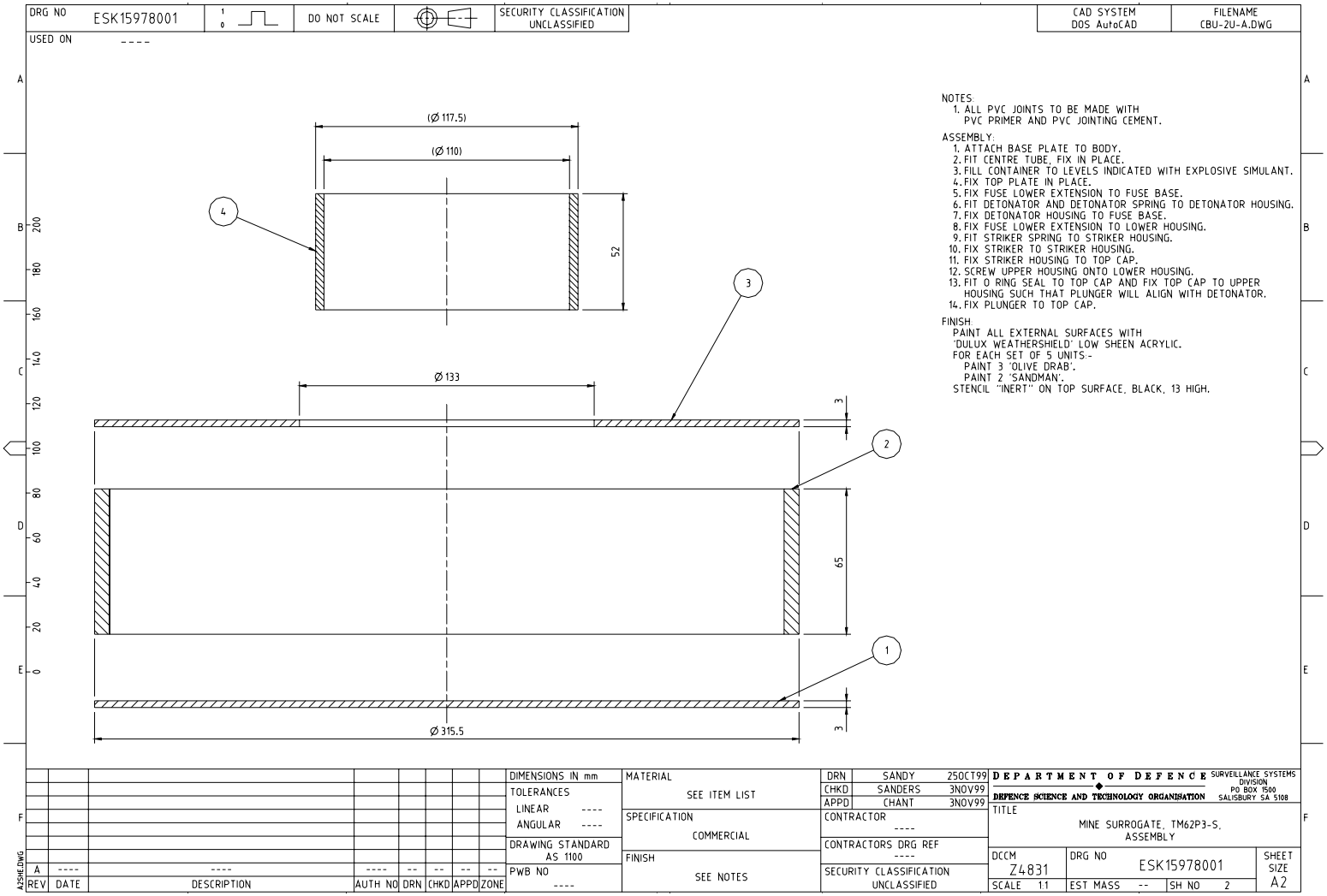

Figure 22: Cutaway drawing of TM62P3-S surrogate landmine (Part B)

Appendix C: DSTO Metal Inserts

DSTO versions of NVESD and DRDC type simulant landmine inserts

- All components are encased in thick walled clear plastic tube and potted in silicon (RTV 3110 preferred)
- Tubes are designed to fit into simulant landmines previously manufactured
- The diameter of the clear plastic tube should not exceed 13 mm, and should be snug fitting into the simulant landmine body
- The inserts should be marked on the top with a type code Identification as given below

Table 11: DSTO (NVDES equivalent) landmine inserts

NVESD Type	Identification	Insert	Levels of Detection *(With Metal Detector)*	Tube Size	Description
A_0	No identification	AP / AT	Not detectable	S	No metal. Only Dow Corning RTV 3110 Silicone
C_0	'W' Black / White	AP	Very Difficult	S	1/8" diameter [0.131g] carbon steel ball
E_0	'W' Blue / White	AP	Very Difficult	S	0.100g carbon steel pin, 0.27" length x 0.062" diameter, vertical
G_0	Red / White	AP / AT	Hard	S	Very small copper tube, 0.5" length x 0.125" O.D. x 0.016" wall thickness [0.393g], vertical
I_0	Dark Green	AP / AT	Hard	S	Small aluminium tube, 0.5" length x 0.187" O.D. x 0.015" wall thickness [0.172g], vertical
K_0	Yellow / Green	AP / AT	Moderate	S	Two (2) parts: 0.100g steel pin from E_0 above and small aluminium tube, 0.50" length x ¼" O.D. x 0.015" wall thickness [0.22g], vertical
M_0	Brown	AT	Moderate	L	Large aluminium tube, 1.5" length x ¼" diameter x 0.015" wall thickness [0.66g], vertical
O_0	White	AT	Easy	L	Four (4) parts: 0.200g steel pin 0.54" length x 0.062" diameter, large aluminium tube from M_0 above, 1.61g carbon steel spring, 1.00" length x 11/32" O.D. with 0.041" diameter (vertical) and a ¼" diameter [1.060g] carbon steel ball

Table 12: DSTO (DRDC equivalent) landmine inserts

DRDC Type	Identification	Tube Size	Description
No.1	Blue	L	Aluminium Cylinder Blasting Cap 6mm x 45mm (0.254mm wall)
No.2	Black	S	Aluminium Cylinder 6mm x 10mm (0.254mm wall)
No.3	Purple	S	Mild Steel Solid Cylinder 4.74mm x 4.74mm
No.4	Yellow	S	Non-Magnetic Stainless Steel Solid Cylinder 4.74mm x 4.74mm
No.5	Brown / Yellow	S	Solid Pin 1.59mm x 19mm Mild Steel
No.6	Red	S	Solid Pin 1.59mm x 19mm Non-Magnetic Stainless
No.7	Orange	S	Brass Ball 4.76mm diameter
No.8	Silver / Grey	S	Steel Ball 4.76mm diameter

S = tube size length to fit small or large landmine casing. If encased in RTV and beverage tube the length should be less than 35 mm.

L = tube size length to fit large landmine casing only. If encased in RTV and beverage tube the length should be less than 65 mm

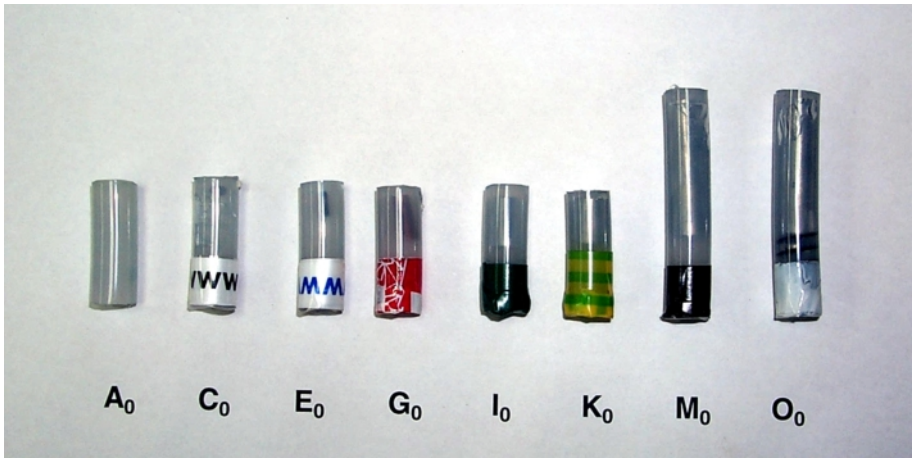

Figure 23: DSTO (NVESD equivalent) simulant landmine inserts

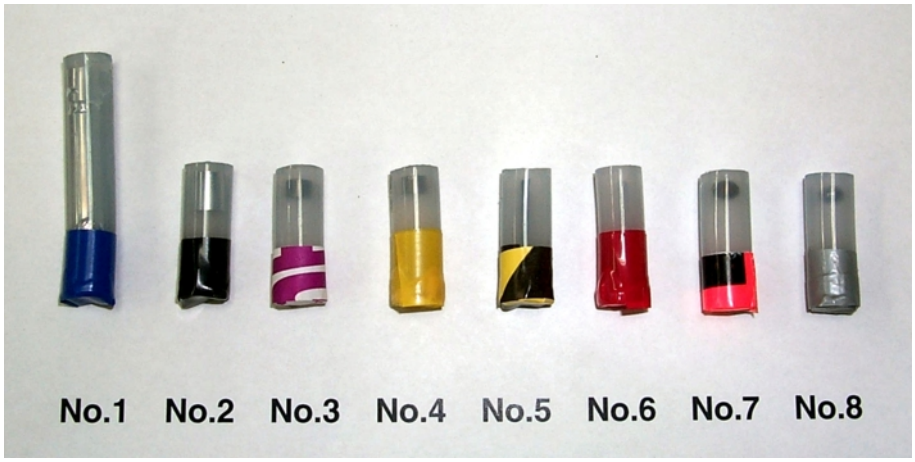

Figure 24: DSTO (DRDC equivalent) simulant landmine inserts

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Ian Chant, Darren Lee and Daryl Ireland

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19. ABSTRACT

DSTO has designed and manufactured a series of landmine test targets to facilitate its active landmine countermeasures program. The targets were developed to simulate specific landmines or to emulate classes of landmines by providing signatures equivalent to those of real landmines. The signatures of the simulant and surrogate landmines were verified against real landmines in a series of experiments involving multiple landmine detection sensors. The test targets are suitable for use with metal detector, ground probing radar, thermal imaging, and seismic/sonic mine detection sensors. Targets are also painted for use on the ground surface with electro-optical imaging sensors. This document details the landmine detection test targets developed by, and available at DSTO Edinburgh, Weapons System Division. Also described are the equivalent targets developed by the United States and Canada. DSTO's test targets, test sites and testing procedures meet the requirements of international test standards.